Science

ATOMIC STRUCTURE

Student Handbook

CLI

CONNECTED LEARNING INITIATIVE

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The **Connected Learning Initiative (CLIx)** is a technology enabled initiative at scale for high school students. The initiative was seeded by Tata Trusts, Mumbai and is led by Tata Institute of Social Sciences, Mumbai and Massachusetts Institute of Technology, Cambridge, MA USA. CLIx offers a scalable and sustainable model of open education, to meet the educational needs of students and teachers. The initiative has won UNESCO's prestigious 2017 King Hamad Bin Isa Al-Khalifa Prize, for the Use of Information and Communication Technology (ICT) in the field of Education.

CLIx incorporates thoughtful pedagogical design and leverages contemporary technology and online capabilities. Resources for students are in the areas of Mathematics, Sciences, Communicative English and Digital Literacy, designed to be interactive, foster collaboration and integrate values and 21st century skills. These are being offered to students of government secondary schools in Chhattisgarh, Mizoram, Rajasthan and Telangana in their regional languages and also released as Open Educational Resources (OERs).

Teacher Professional Development is available through professional communities of practice and the blended Post Graduate Certificate in Reflective Teaching with ICT. Through research and collaborations, CLIx seeks to nurture a vibrant ecosystem of partnerships and innovation to improve schooling for underserved communities.

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ATOMIC STRUCTURE

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Content

Why Chemistry

1.1 Why Chemistry

Wow, Chemistry!

Is it possible to think of life today without chemistry?

Just look at the world around you and the materials that we use today.

Modern medicine, cement, petrol, synthetic clothes, paper, new kinds of metals, computer, mobile phones, the microprocessor and memory chips, the screen of your television and computers….all these exist due to development in chemistry.

Aren't these central to our existence today?

This is the 21st century. Imagine for a moment that you are in the 18th century.

Which of these things or materials would you not find in the 18th century life?

What is Chemistry?

Chemistry helps us understand two fundamental facts –

- The structure of a substance
- The way substances bond to form new substances

Chemists work in pharmaceutical companies producing medicines, even creating new medicines. They work in food processing industries to create new processes to preserve food for longer duration using chemicals. They work in metallurgical industries and create processes to get more and more metals out of an ore. They work in textile industries; they are the ones who create new kinds of fibres useful under special conditions. They work in foundries creating silicon chips to be used in our computers and phones.

People who work in a specialised area develop their own language with its system of symbols and signs. It helps them communicate within the community better, creating a standardised system. So do chemists have a special language. The language in Chemistry uses English letters to denote names but their origin may be Latin, Greek, etc. These letter symbols may also carry numbers that signifies a value. In Chemistry, like in any developed area of study, there are methods and rules which we shall learn as we go along.

1.2 Periodic Table

The Periodic Table of Chemical Elements

Group→ ↓Period	1	2	3		4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 H																		2 He
2	3 Li	4 Be												5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg												13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	19 K	20 Ca	21 Sc		22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 Rb	38 Sr	39 Y		40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba	57 La	*	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra	89 Ac	**	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og
				*	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu	
				**	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr	

This table is known as the Periodic table of Elements. Elements are the most basic substances that make up matter

This is an amazing treasure. It has information hidden in it about the substances / matter that make up our world. This information has been arranged in rows and columns

In order to read, it we have to learn the Language of Symbols in chemistry

Look carefully. In every box, there are a couple of English letters and on their top side is a number.

Perhaps, we recognise some of them.

Look at the first box in the first column. It says H - this indicates Hydrogen. Hydrogen is a gas - perhaps you are familiar with the name. Above 'H', there is a number '1' written. Soon we will get to know what this means

Now look at the first box in the 16th column. O is the symbol for Oxygen. Where did you hear of Oxygen

Now look at the third box in the first column and the second box in the 17th column. You will find Na and Cl respectively. 'Na' stands for Sodium and 'Cl' for chlorine. Sodium is known as Natrium in Latin. That is why the symbol for sodium is Na.

You might know that the common table salt or edible salt is known as NaCl or Sodium chloride in chemistry? NaCl is the formula for table salt. The formula indicates that table salt is made up of Sodium and Chlorine. We read this formula as N-a-C-l.

And, what do you think of H2O? This is the chemical formula for water. It is read as H-2-O. This formula tells us that water is made of Hydrogen and Oxygen. They are both gases, but when they exist together in a particular ratio, they become liquid (water). Isn't this interesting?

Look at the second box in the 14th column. Si – Silicon. Does that sound familiar? Chips or processors of Memory cards, computers, mobiles are made of this.

And now look at the fourth box of the 15th column. P - Phosphorous; this is an essential component of our bones, matchsticks, firecrackers. Here's something interesting - it was first found in human urine!

Just like phosphorus, the discovery of every element has an interesting story behind it. We shall get to know some of these stories.

Chemists believe that the entire world is made up of only 118 elements. In the periodic table these are arranged in a particular sequence/ order. Around 94 elements are found in nature and rest of them have been synthesized in laboratories.

You might wonder - How did they know that there are only 118 elements in the world?

Let's start with the getting to know the elements.

1.3 What is an element?

Do you find salt (NaCl) in the periodic table? But you do find Na and Cl, isn't it ?
Do you find H2O in the table? But there is H and O

Separation

You can separate salt from a mixture of salt and sand, isn't it ?

The process of sorting substances from one another in a mixture is called separation. We apply the separation technique often in our daily lives.

If you have two or more substances present together and they can be separated easily, we say the substance is impure or it is a mixture of substances.

On the other hand, if the substance cannot be separated any further using any method, we can say that the the substance is pure or it is made up only that substance.

But there is a problem in defining a pure substance in this way. You may have tried your common knowledge of methods to separate the substance and the substance is all you get. So you may say that the substance is pure. But it is possible that a scientist could discover a new method of separating such a substance in future. It is possible that the substance you thought was pure today could then be separated into different and new substances, using this new method.

Consider this example. You draw water from a well and pass this water through a filter paper. The water passes through without leaving a deposit. What would you conclude at this stage about the purity of this water?

What would you conclude at this stage about the purity of this water?

Next, you heat this water. All the water evaporates, leaving behind some deposit.

Would you still conclude that this water is pure?

This is what has been going on in the chemistry world. Chemists have been working in this manner with several substances and discovered new ones
For example when you apply electrolysis, you find the water can be broken down or separated into hydrogen and oxygen. Since you cannot further separate hydrogen and oxygen, you believe that they are the fundamental constituent substances. We started calling them Elements. *
(about electrolysis)

Let's learn about the discovery of phosphorus

The period was 17th century.

It was believed that human urine may contain the Philosopher's Stone, that has the ability to turn any metal into gold. It made an alchemist in Germany very curious. His name was Hennig Brand. He wanted to find a method to separate this Philosopher's Stone from urine.

This is what he did -

He let the urine stand for days until it gave off a terrible smell. Then he boiled it down to a thick paste. He heated this paste to very high temperaure and let the vapours cool under water. The vapours cooled to form a waxy substance that glowed in the dark‼!

This was Phosphorus, the 13th element discovered.

In this way, chemists tried to separate substances using every known method available. When the substance could not be separated further, they concluded that they had found the basic substance or the building blocks of the matter around us. These fundamental substances were called Elements.

The discovery of these elements led the scientists to another question about the differences among these elements. For example, how does hydrogen differ from oxygen? But before we find that out, let's learn about the naming of these elements

1.4 The language of chemistry -I

You may have observed that different substances have different names in different languages. For example, iron is called loha in Hindi while copper is called tamba. Water also has several names, like pani, jal, neer, etc.

Having so many names for substances could create problems in a field like chemistry where work is conducted throughout the world. How would scientists from different countries who speak different languages communicate with each other? There should be some way in which they can understand each other. To make this possible, we must have universally accepted names for different substances. That is, a scientist from any part of the world should be able to recognise the substance by its name.

Many elements like iron, gold, silver, mercury, copper and zinc have been known since ancient times. But many other elements were discovered in recent times.

When a new element is discovered, the discoverer gives it a name. That becomes the name of the element. When modern chemistry was being developed, the language most commonly used among scientists was Latin, the language of ancient Rome. Thus the names of many elements were based on Latin words. Take the example of hydrogen. One of the properties of this gas is that it combines with oxygen to form water. The Latin name for water is 'hydro'. So this gas was named hydrogen, which means, "gas that makes water".

The story of oxygen is very interesting. At one time people believed that any compound that contained oxygen would be acidic in nature. The Latin word for acid is 'oxy'. Hence the gas was called oxygen, meaning "gas that forms acid". It was later discovered that acidic property was not related to oxygen. However, by then the name had come into common use so it was not changed. After all, what's in a name?

Another case is that of helium. This gas was first discovered in the Sun, not on Earth. The Greek name for sun is 'helios', so the gas was named helium.

Many elements were named after the places in which they were discovered. Some examples are scandinavium Scandium and Californium. Scandium was discovered from the minerals found in Scandinavia region of northern Europe in 1879; whereas Californium was synthesized in a university laboratory in California, United States of America.

Some elements were named to honour well known scientists. One example is Mendelevium, named after Gregor Mendel.

The names of many elements are their English names as well.

For example, the chemical names aluminium, carbon, oxygen, nitrogen and hydrogen are also the English names of these elements. However, this is not always the case. The chemical name ferrum is called iron in English while cuprum is copper.

The next step in naming elements was to write them in an abbreviated form. Thus, carbon was given the symbol of a capital C. Generally, the first letter of the name of the element became the symbol of that element. For example: H for hydrogen, O for oxygen

and N for nitrogen. But this caused a problem. There are many elements whose names begin with the same letter. Examples include copper, carbon, calcium and chlorine, which all begin with the letter C.

Can you suggest a way in which this problem could be solved? Should the names of these elements be changed?

No, the names of the elements were not changed. In these cases, instead of using only the first letter of the name, the second or any other letter was added to it. So while carbon became C, cuprium became Cu, calcium became Ca and chlorine became Cl.

Here, too, it is necessary to remember one thing. When two letters are used to form the symbol of an element, the first letter is written in upper case or capitalized while the next letter is in the lower case. So the symbol for calcium would have a capital ‘C’ and a lower case ‘a’ to form Ca.

So do we have to memorize these formulae?

No, no, we don’t; we will be able to remember them as we repeatedly use them.

1.5 The language of chemistry -II

There is one more variation. The symbols of some elements are not assigned according to their English names but according to their Latin names. For example, the symbol for sodium is Na which is derived from its Latin name ‘natrium’. Similarly, K, the symbol for potassium, is derived from ‘kalium’, and Fe, the symbol for iron, is derived from ‘ferrum’.

The names and symbols of some elements are given in the following table:

You may have noticed that names of some common substances like wood, sugar, bronze, paper, plastic, etc, have not been included in the table. This is because these substances are not elements. You will, perhaps, be surprised to know that bronze is not an element but a mixture of copper and zinc..

Are you wondering whether these substances have symbols or not? Do they have abbreviated names or not? The answer is yes, they do. But before discussing these symbols, we need to look at one more aspect.

Name of an element	English names	Latin name	Symbol
Aluminium	Aluminium		Al
Calcium	Calcium		Ca
Carbon	Carbon		C
Chlorine	Chlorine		Cl
Chromium	Chromium		Cr
Silver	Silver	Argentum	Ag
Copper	Copper	Cuprium	Cu
Sodium	Sodium	Natrium	Na
Gold	Gold	Aurum	Au
Hydrogen	Hydrogen		H
Iodine	Iodine		I
Iron	Iron	Ferrum	Fe
Nitrogen	Nitrogen		N
Nickel	Nickel		Ni
Oxygen	Oxygen		O
Phosphorus	Phosphorus		P
Sulphur	Sulphur		S
Potassium	Potassium	Kalium	K

Could you find out about other elements and if the source of their symbol is their English or Latin name?

One advantage of using symbols is that we don't have to write the full name of the substance every time we refer to it. There is another advantage. When we use the full name of a substance, say 'iron', we do not know the quantity of the substance. But when we write its symbol Fe, we know there is only one atom of iron. This represents the equivalent amount of this substance of the atomic weight of iron. To similarly show two atoms of iron we write 2Fe

How will you show three atoms each of carbon, silver and gold?

Need of the Atom

2.1 Need for an Atom-I

The Challenge of getting an Element in its free state!

Why don't we find elements in their free state?

We had read in the last chapter, that chemists had reached the conclusion that there are some basic elements that generate a variety of substances. They are 118 in number.

But it had also became clear that most of the elements are not naturally found in the element state. They are always found combined with another element.

Let us watch a video. In this video, you will see the element Sodium being cut. Look carefully at the layer that is cut and observe any changes on it.

Is there any change in the glow/shine of Sodium?

The reason for the shine to diminish can be chemically expressed as-

Sodium + Oxygen = Sodium Oxide

The element Sodium started reacting with the Oxygen present in the air and became Sodium Oxide. Due to this chemical reaction, the upper layer became dull/stopped shining.

Perhaps some of you will have an iron kadahi/wok/or deep frying pan at home for cooking vegetables. When we wash it and keep it aside, it gets rusted.

If you keep any iron object outside for a few days, it gets rusted.

Iron + Oxygen = Iron Oxide (the oxide of iron)

Phosphorous is an integral component of life. You have seen that phosphorous is found in bones and urine. It was first obtained from human urine. It is used in fields as a manure in the form of phosphate.

However, in nature, it is never found in its pure or elemental form. We find it as Calcium Phosphate in rocks.

Phosphorous + Calcium + Oxygen = Calcium Phosphate

You have now seen the three elements, Sodium, Iron and Phosphorous - they react chemically under standard temperature and pressure, as they are active in nature.

The substance that is formed after the chemical reaction is not reactive any more. It is stable.

For example, Sodium in its element form is very reactive. Whereas, in the form of Salt it is non-reactive.

Even pure iron starts reacting with oxygen very fast and becomes Iron oxide. Iron ore, from which we obtain iron, is usually in the form of Iron oxide.

Now take a look at the elements in the 18th column of the Periodic Table. They are known as Noble or Inert Gases. These are found in their element form in nature. They are stable and under standard conditions they are non-reactive.

When a substance is made of two or more than two elements and its physical and chemical nature is different from that of the original basic elements, it is known as a compound.

Salt is a compound, made of Na and Cl. Chlorine in its basic nature is a light yellow gas and sodium is a shiny solid. When both combine, we get a solid salt and its nature is very different from that of either of them.

Similarly, water is also made of H and O. In their basic state, they are both gases, whereas water is a liquid.

Look all around you - you will find lots of compounds. Even if you search hard for elements, you won't be able to find them.

Elements can be separated from their compounds only through chemical processes.

Here are some facts to remember -

1. Some basic elements are stable, i.e. they are found in their pure form. Their numbers are very few. For example, the inert, non-reactive gases in column 18.
2. Most of the elements are found as compounds in nature, which are made of two or more than two elements. For instance, Iron - in the form of iron oxide, Sodium - sodium oxide and other forms, Phosphorous - in the form of Calcium Phosphate.
3. Compounds are stable as compared to elements.

Now we have found some more questions for which we need to find answers

1. Why are inert gases, which are also called noble gases, non reactive and stable?
2. Why are certain elements like Sodium, Calcium and Iron, reactive?
3. Reactive elements do not combine with any and every element to form compounds. Is there a logic/plan to the process of making compounds?

If we understand the logic/plan of making compounds, maybe we can make a new compound?

2.2 Need for an Atom-II

The need for an atom

You may have heard of an Atom.

Can you show or draw it in your book?

Now that we have understood elements and compounds, let us find out how they react with each other. But first, we need to understand what is an atom.

An atom is the smallest particle of an element. We cannot see it with the naked eye. And usually

they do not exist in their free state.
Take hydrogen gas for instance. If we imagine that we have the smallest particle of gas, you will get two hydrogen atoms combined together.

When two or more atoms are combined together, we call it a molecule.

Why is it that under normal temperature and pressure, we find molecules of Hydrogen and Oxygen - not atoms?

Atoms do not combine only with atoms of their own element.

Take salt for instance - if we take the smallest particle/unit of salt, we will find an atom of sodium and an atom of chlorine combined in it.

The smallest particle of water will have two atoms of hydrogen combined with one atom of oxygen.

The smallest particle/unit of water and salt will also be called a molecule since it has more than one atom combined in it.

There are several such examples which we shall discuss later.

Let's go back to a question we raised a little earlier-

1. **Why cannot atoms of most of the elements exist independently?**

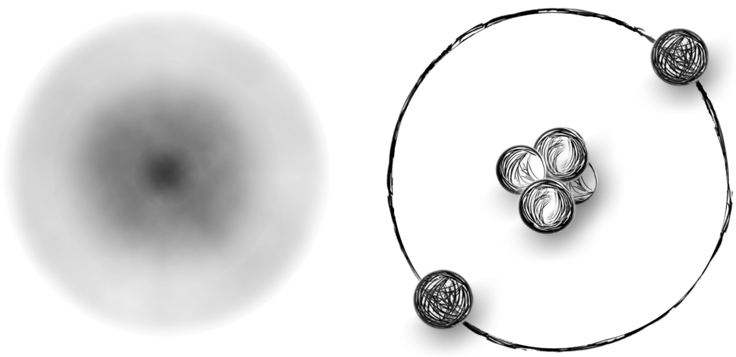
2. **When an atom combines with atoms of other elements, what is it able to achieve?**

If we find answers to these questions, we might be able to understand the chemically reactive nature of elements and the formation of compounds.

Moreover, we might uncover a very big secret of Nature!

Atom and Atom Factory

3.1 Atom



Atoms are made of three basic particles. At the centre of the atom, there are neutrons and protons. Whereas Electrons revolve around it.

The electrons move with such speed that it is impossible to tell where exactly an electron is at any time.

Scientists have prepared a model of the atom to make it easier for us to understand and visualise the atom and its various parts. So don't mistake this model for the actual atom.

About the Atom

At the centre of the atom are the protons. These carry positive charge.

Also present in the centre are neutrons. They carry no charge. The centre including the proton and neutron is also called the nucleus.

The number of protons in any atom is known as the Atomic number of that element. The Atomic number of every element is different as the number of protons in every element varies. You will notice that the elements have been arranged in increasing order of their Atomic numbers in the structure of the Periodic Table.

Protons and neutrons are the heaviest part of the atom. They are almost equally heavy.

When we talk about the mass of an atom, this is roughly the mass of protons and neutrons in the nucleus of that atom. In the total mass of the atom, the contribution of the mass of electrons is negligible.

Electrons orbit around the nucleus in their different energy levels. In reality, it is very difficult to predict/say where a particular electron will be at any point in time. In fact, one can only guess the probability of finding an electron in the vicinity of the nucleus.

Just for simplification, we show the electrons revolving around the nucleus in orbits.

In scientific terms, this is referred to as the model of an atom and not the actual form of it.

So lets try and make the model of an atom from what we have learnt till now.

3.2 Atom Factory

The Atom Factory An introduction to the App (Build an Atom)

In order to build an atom you will use an app.

You have some electrons, protons and neutrons in the baskets given below. With the help of these you will build atoms.

Along with this you have also been given the Periodic Table. As you keep making the elements, their place in the periodic table will also get highlighted.

While making atoms in the Atom Factory, observe what is happening and think about the questions given below -

Points of Observation

1. When you get the protons to the nucleus, is any kind of charge attained?
2. How many electrons do you need to add to make this atom neutral or charge-free?
3. If the number of protons are changed, what happens?
4. If the number of neutrons are more or less, what indication is given in the Simulation?
5. In between, you also alternate visualisation of energy levels between the orbital and electron cloud models

In the ***computer lab***, to enter the atom factory please click on the button given below

3.3 Atom factory again!

Come, let us visit the Atom Factory again!

Now we will again try and make an Atom - keeping certain things in mind.

Rules

1. You have to build a stable atom. In this atom, the number of electrons should be equal to the number of protons. This way, the atom will not have any charge.

2. In certain elements the number of neutrons are more than the number of protons. While making the atoms, you will come across such an element as well. If the number of neutrons are more or less than the protons, the atom will be unstable.

Now look at the Electron

You must have noticed that the electron can be established at various energy levels. Perhaps you have filled in only the first or second energy levels. However, there can be more than two energy levels as well.

How many electrons can a particular level have - is there any limit to that?

How many electrons were able to go to the first level? Two or four or eight?

How many were able to go to the second level? Two or four or eight?

In the Atom Factory app you will be able to make atoms of only ten elements. Once you have made them, do not forget to answer the following questions.

In the ***computer lab***, to enter the Atom factory click on the button given below

3.4 Review Atom

Review what you have learnt!

We hope that you have enjoyed building atoms in the factory. Surely you must have taken some notes too. Now try to answer the questions given below.

Just remember that here when we talk about a stable atom we mean that the atom has no charge on it.

1. **How many energy levels does a stable hydrogen atom have and how many electrons are there in a stable hydrogen atom?**
2. **How many energy levels does a stable helium atom have and how many electrons does it have in all?**
3. **How many energy levels do the electrons of a stable carbon atom have? How many electrons are there in its outermost energy level ?**
4. **How many energy levels of electrons are there in a stable oxygen atom and how many electrons are there in the outermost energy level?**

3.5 Electrons and chemical reactivity of an element

Chemical reactivity of an element

A chemist would first of all like to know how many electrons there are in the outermost energy level. This tells them about the chemical nature of the element. So while studying chemistry, pay attention to how many electrons there are in the outermost energy level.

How does it help to know how many electrons there are in the outermost level ?

You have seen while cutting sodium - its shiny surface becomes clouded when exposed to air. But why?

We do not find the element hydrogen as an atom on Earth. We get it in the form of a H2 molecule. We find this H2 in air in the form of a gas. H2 means two atoms of hydrogen combine together. Similarly, Hydrogen exists in the form of other compounds as well, in which it combines with atoms of other elements, for example - HCl, H2O, NH3, etc.

Why is it so?

Oxygen is also not found in the atomic form either on Earth - that is, only in the form of O. Oxygen too is found in the form of O2. It combines with various other elements and is also found in the form of compounds, for example, H2O, SO2, Na2O, CaO, etc.

Now take water, H2O, for example. As you can see, it is a compound made of hydrogen and oxygen.

We find sodium in the form of (natural salt or table salt) NaCl or in the form of other compounds. In NaCl too, the sodium atom is combined with the chorine atom. Why are sodium or chlorine not able to stay independently?

Iron also is not found in the form of pure Iron. It is mostly found as iron oxide.

The same is true of aluminium - aluminium is mostly found as aluminium oxide.

Why is this so?

In order to understand the answer to this question, we need to understand the chemical reactivity (chemical nature) of elements vis-à-vis one another. Chemical Reactivity depends on the number of electrons present in the outermost energy level of the atom of an element. Let’s try and understand it a bit more.

The rule of 8

4.1 The rule of 8

The rule of 8!

Let us take a look at the Periodic Table once again.

Look at helium and neon.

In the periodic table the elements found in the 18th or 0 group are in the gaseous form, under normal temperature and pressure conditions. They are called Noble or Inert Gases. Why are these gases given this name? We shall see the reason as we read further.

Helium is a Noble gas and neon is also a Noble gas.

In the atom factory, you have also made the helium atom.

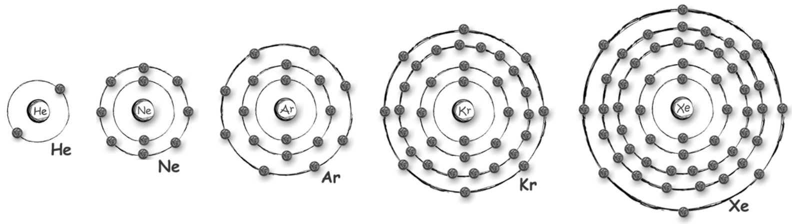
The helium atom has only two electrons and both of these fill up in the first shell (energy level). The capacity of the first shell is also actually that of only two electrons.

You have also made the Neon atom.

Neon has a total of ten electrons. Out of these, two fill up the first energy level which has a capacity of two only and the remaining eight completely fill up the second energy level which has a total capacity of eight electrons.

Take a look at the atoms of the other Noble gases shown below. Also observe the number of electrons in the outermost shell.

In these too, you will find the number of electrons is - eight!



We find these gases naturally in their atomic form: Helium - in the form of helium atom, Neon - in the form of neon atom.

In nature, it is very rare to find these elements combined with some other element in the form of a compound.

They do not combine with any other element. If you specially try to combine these gases with some other element in a laboratory, it is still not easy to do so.

With these learnings in mind, scientists came to the conclusion that if the outermost shell of an atom is full, the atom/element is inert and it is not easy to make it react with any other element. This is also known as the Octet Rule, since all inert gases, except helium, require eight electrons in the outermost shell for it to be full.

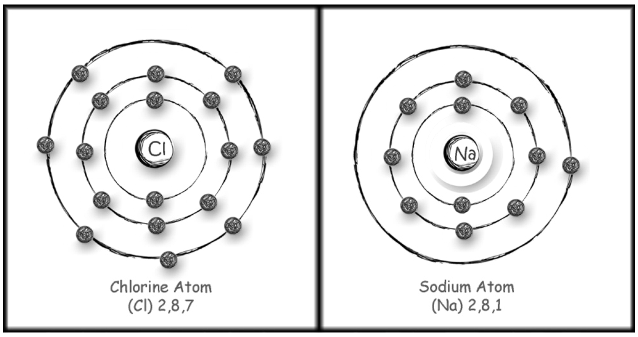
The outermost shell requires eight electrons for the shell to be full. This is called the Octet Rule.

Is there any link between the total number of electrons in the outermost shell and the chemical reactivity of the element?

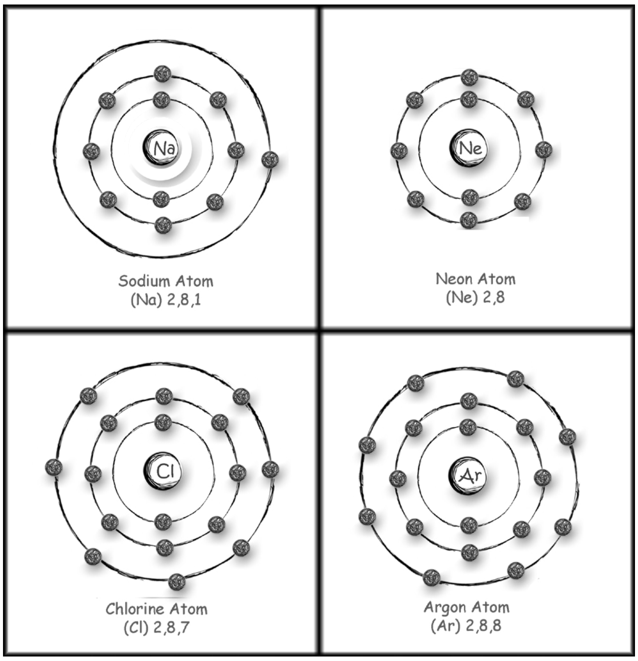
4.2 Na and Ne- Cl and Ar

Na & Ne - Cl & Ar and Ionic bond

We know that the sodium atom has 11 electrons. Thus the first two shells fill up completely with two and eight electrons respectively and the eleventh electron comes into the third shell. So the electronic structure or configuration of a sodium atom becomes (2,8,1). Now lets take the chlorine atom. A chlorine atom has a total of 17 electrons. These fill up in the first, second and third shell in the electronic configuration 2,8,7. In this way, we get one electron in the outermost shell of sodium and seven electrons in the outermost shell of chlorine.



If, in some way, sodium and chlorine get 8 electrons in the last shell, they will both become inert/non-reactive and chemically stable like the noble gases.



That is what happens - all elements in the Periodic Table want to get an electronic structure like the Nobel gases and become chemically stable.

For that to happen they require eight electrons in their outermost shell.

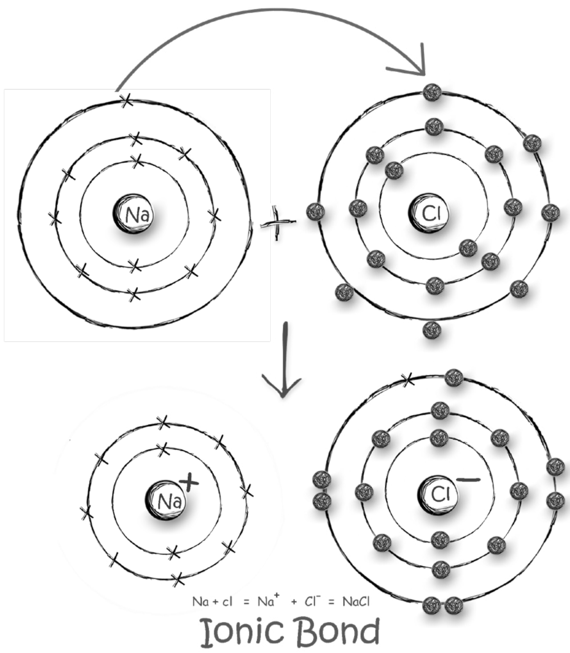
Now, the number of electrons cannot be changed so easily. After all, nature does not work like our app!

Generally, in nature, elements are ready and willing to combine with those elements with whom they can either share or give or take a specific number of electrons in such a way that in every outer orbit there are eight electrons..

Apparently, this is also the reason for their chemical reactivity.

So when sodium and chlorine are brought together, the sodium atom immediately gives its outermost electron to the chlorine atom. This way the sodium atom is now left with an extra +1 charge and its electronic configuration becomes (2,8) which is like the structure of the inert gas, Neon, which is closest to it. Now instead of calling it a sodium atom, we will call it a sodium ion. Its chemical nature is very different from that of a sodium atom. In the same way, after accepting an electron from sodium, chlorine has one extra (-1) charge and its electronic configuration becomes (2,8,8) which is the like the electronic structure, (2,8,8) of the inert gas, Argon, closest to it. Now we will call it the chlorine negative ion instead of the chlorine atom. Its chemical nature is very different from the chemical nature of the chlorine atom.

In the end, the sodium positive ion and the chlorine negative ion get attracted by the electronic force and form sodium chloride (NaCl) or common salt which is a compound.



So the bond that is formed between the sodium ion and the chlorine ion to form NaCl compound, is called an Ionic Bond.

Sometimes, electrons in the outermost shell of an atom are shown by big dots and sometimes by crosses. Whenever we make a new molecule, we should be clear about which electron is from which atom and how many electrons are shared by which atoms. What matters for you is the number of electrons.

As we have seen in the earlier paragraph how the atoms of Na and Cl have a tendency to change their electronic configuration to that of the atoms of the inert gas closest to them. This tendency respectively converts them to Na+ and Cl- ions and finally the electronic (or electrostatic)? Interaction between these positive and negative ions results into a molecule of NaCl.

As a result of this entire process we can see that the atoms of Na and Cl elements combine with one another and form a new particle of a new substance, NaCl. This new particle which is made by the combining of two or more atoms is called a molecule. In this example of NaCl given above, we will call the kind of bond formed between Na and Cl as Ionic Bond.

There are other common examples of substances being formed as a result of this Ionic Bond; sodium flouride (NaF), potassium chloride (KCl), calcium chloride (CaCl2)

Just like NaCl, can you draw the process of making the above mentioned substances from their basic elements, in your book?

4.3 H & He - O & Ne

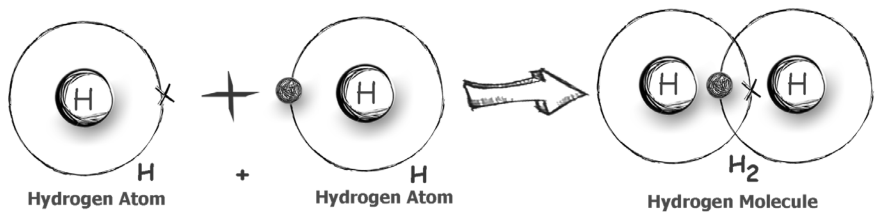
H & He - O & Ne and co-valent bond

Now we will learn another method by which atoms of elements combine to form molecules of a new substance. Come, let us understand this with the help of an example given below

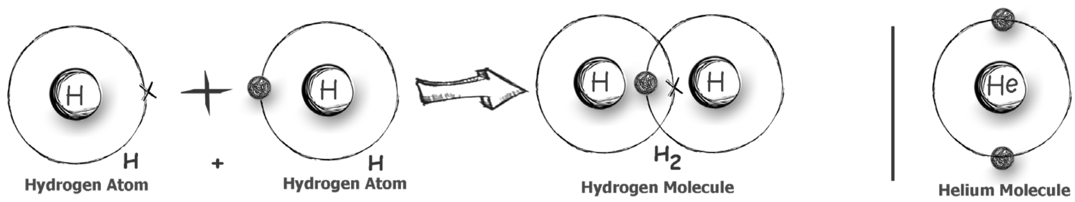
Making of an Hydrogen atom

We know that the Hydrogen Atom has only one Electron which orbits in the first shell. Observe that the closest inert gas to hydrogen according to the Periodic table is helium. We have learnt earlier that the two electrons of helium totally fill up the first shell. (Remember, that the first shell of an atom has a capacity of a maximum of two electrons). So the two atoms of hydrogen, each having one electron, share these two electrons in such a way that both electrons stay in between both atoms and are attracted by both positively charged nuclei.

Due to this sharing of electrons, there are two electrons around each hydrogen nucleus and their configuration resembles that of the helium atom. So the hydrogen element is chemically more stable as a molecule H2, as compared to the atom H. That is why, on earth, under normal temperature and pressure conditions, the element hydrogen is mostly found in the form of H2, a molecule. The bond that is formed between the atoms by sharing of electrons is known as a Covalent Bond.



Formation of an Hydrogen Molecule: an atom shares an electron with another atom. the formation is a molecule, which is more stable than an atom.

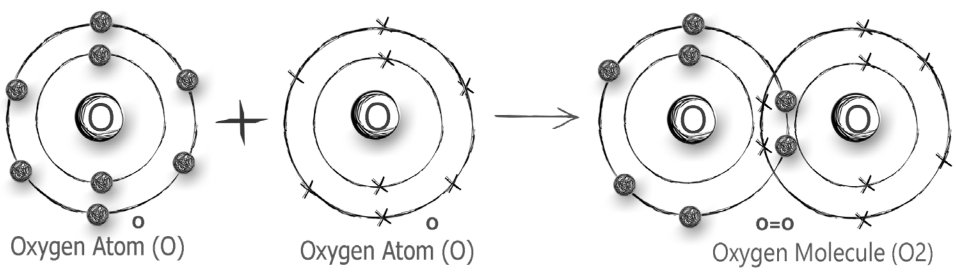


The electron configuration around each molecule of Hydrogen is like that of the Helium atom.

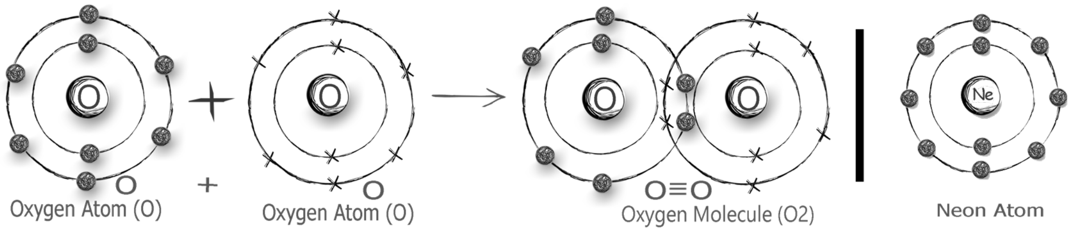
Other examples of elements formed by covalent bonding are O2, Cl2, NH3 etc.

Making of an Oxygen Molecule

Every atom of oxygen shares two electrons with another atom, which forms the oxygen molecule. The outermost shell of this molecule has the same number of electrons a as Neon. Neon has eight electrons in the outermost shell. Now we can say, when a molecule of oxygen is formed, its outermost shell gets eight electrons and its electronic configuration resembles that of neon.



Formation of an Oxygen molecule: sharing of two electrons by each atom with each other.



Electronic configuration of the Oxygen molecule is like that of the Neon atom.

Note: *Sometimes, electrons in the outermost shell of an atom are shown by big dots and sometimes by crosses. Whenever we make a new molecule, we should be clear about which electron is from which atom and how many electrons are shared by which atoms. What matters for you is the number of electrons.*

Molecule Factory

5.1 Molecule Factory

Molecule Factory

In the previous section we learnt that atoms combine to make a molecule. Now we will go to a molecule factory. In this factory you can make many kinds of molecule - some of known compounds and some are unknown compounds.

Unlike 'Atom Factory' , here you will get the whole atom as a building block to your molecules. These atoms lie in baskets. You will have to drag and drop the right number of atoms in the empty area to make molecules that you are expected to make.

If your construction is right, the place where you have to place this molecule will get highlighted.

Here you will also learn that it is not just about the right numbers but how do you place atoms vis-à-vis other atoms that also matter. Atoms joins other atoms in a unique way sometimes.

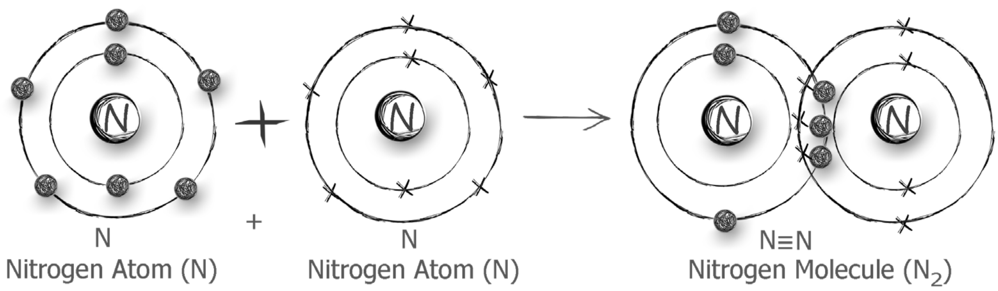
<u>Let the play start!</u>

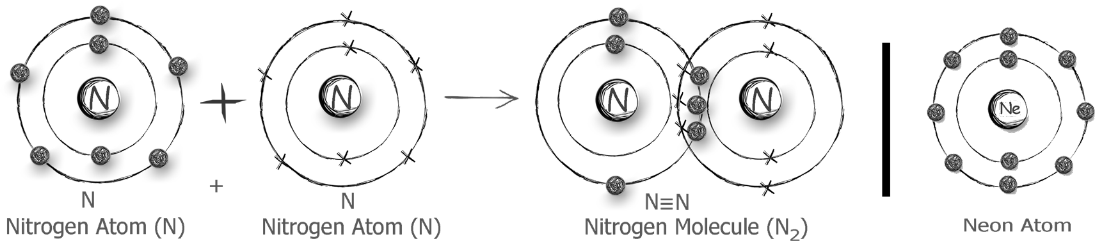
In the ***computer lab***, click on the button to enter the factory.

5.2 Some more molecules

Let's make some more molecules

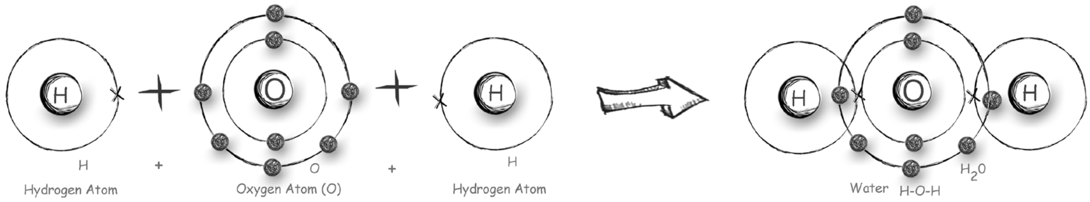
Nitrogen Atom





The electronic configuration of a molecule of nitrogen which is like the electronic configuration of a neon atom.

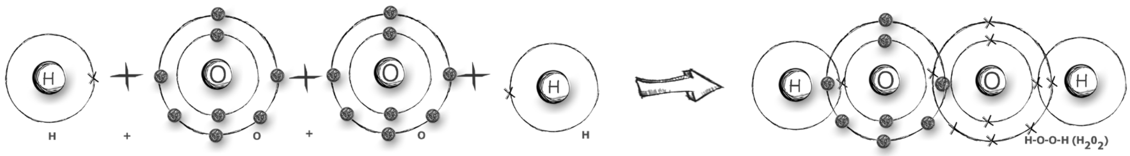
Water molecule



Formation of water molecule

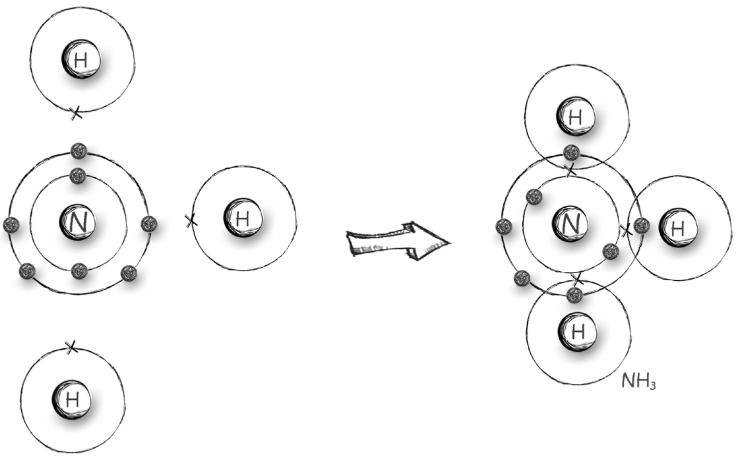
Hydrogen Paroxide molecule

When two hydrogen atoms, which have an electron each in their outermost shell, come close to two atoms of oxygen, one atom of hydrogen gives its single electron to one atom of oxygen and completes its electronic configuration and the other hydrogen atom also gives its single electron to the other atom of oxygen. Now these two atoms of oxygen which already have a hydrogen atom, share an electron each and complete their outermost shell with eight electrons. As a result we get one molecule of hydrogen peroxide (H2O2).



Ammonia Molecule

Now let us talk about the Ammonia molecule. We know that the nitrogen atom has 5 electrons in the outermost shell. It requires three more electrons to get the total of eight in the outermost shell. It fulfils this requirement with three electrons from three Hydrogen atoms - that is, one from each. It shares one electron each with each atom of hydrogen, which makes two electrons in the



Amonia Molecule

outermost shells of the hydrogen atoms. The outermost shell of Nitrogen also gets eight and a molecule of Ammonia is formed.

To do:

Now you all can try and make bigger molecules like methane (CH4), carbon tetrachloride (CCl4), ethane (C2H6) with the help of these dot or crosses diagrams. While constructing them, you need to think which inert gas' electronic configuration are the molecules resembling? You need to keep in mind that whenever you make molecules by sharing, the outermost shell should have eight electrons (Hydrogen should have two).

This will strengthen your understanding of sharing of electrons.

Note: Sometimes, electrons in the outermost shell of an atom are shown by big dots and sometimes by crosses. Whenever we make a new molecule, we should be clear about which electron is from which atom and how many electrons are shared by each atom.

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